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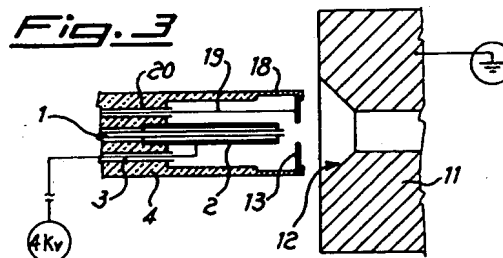
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(54) **Method and device for interfacing liquid chromatography or supercritical fluid chromatography with a mass spectrometer (LC-SFC/MS).**

(57) A method for interfacing LC or SFC chromatographic equipment with a mass spectrometer, comprises the steps of: positioning at least one conductive element (2) adjacent said column end (1); positioning said column end (1) and said conductive element (2) at a preselected distance from the mass spectrometer ion source (11); and connecting said conductive element (2) to a high voltage source and grounding said ion source, or viceversa.



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The invention also provides a device for interfacing an LC or SFC chromatographic equipment with a mass spectrometer, comprising means to generate an electrostatic field between said column end and the spectrometer ion source to nebulise the eluent exiting the column end, characterized in that it is further comprising:

at least one conductive element positioned adjacent to the column end;

means to alternatively connect said conductive element to a high voltage source or to ground them;

said element and connecting means being at least partially positioned within insulating means located at one end of a guide tube housing the end portion of said chromatographic column.

According to an advantageous embodiment of the invention, said conductive element is located around the chromatographic column outlet and preferably consist of a thin layer of metal directly deposited on the column end.

This metal is most preferably gold. Said insulating means, such as teflon or machinable glass, and guide tube housing the end portion of the chromatographic column are advantageously part of a probe that is insertable as a whole unit in the mass spectrometer to act as interfacing means.

According to another advantageous embodiment the actual interface comprises also a focusing plate that is positioned between the column end tip and the ion source.

This plate is held at a voltage that has an intermediate value between the conductive element value and the ion source value.

Alternatively, the eluent may be nebulised directly into the evacuated ion source.

The peculiar configuration of the invention device enables its use with different kinds of mass spectrometers.

Namely, when used as interfacing means with a magnetic sector MS, the conductive element is grounded and the ion source of the MS is held at a high, usually positive, voltage (e.g. 5 Kv).

When the invention device is used with a quadrupole spectrometer, the MS ion source is grounded or kept at a low potential with respect to the conductive element to which is applied a high, usually positive voltage (e.g. 4 Kv).

The invention will now be further disclosed with reference to the drawings herein enclosed to an illustrative and non limiting purpose, where:

- fig. 1 is an enlarged sectional view of a portion of a preferred invention embodiment;
- fig. 2 is a partially sectional view of fig. 1 embodiment in use;
- fig. 3 and 4 are schematical views of two different operating modes of the invention device;
- fig. 5-7 are schematical views of possible

different embodiments of the conductive elements of the invention device;

- fig. 8 is a total ion chromatogram of a LC/MS separation of a mixture of polycyclic aromatic hydrocarbons; and

- fig. 9 is a comparison of EI and library spectra of a component of fig. 8 mixture.

In the following description "column" and "chromatographic column" wording indicates the actual column of the LC or SEC equipment, or a transfer line connected to said actual column.

Both of them are usually provided with a restriction, in a way known in the art.

Similarly, "conductive element" indicates any element to which a high voltage may be applied, or that may be grounded in a way known in the art, "Grounding" means that the element is actually grounded or held at a very low voltage.

With reference to fig. 1, the invention device essentially comprises at least one electrically conductive element 2 positioned close to the end of the column 1. Element 2 is provided with a connector cable 3 or similar connecting means to either ground the conductive element 2 or to connect it to a source of d.c. high voltage (not shown). Element 2 is partially housed within insulating means 4, usually made of teflon, machinable glass or similar insulating material.

As disclosed in figures 1 and 2, insulating means 4 are located at the end of a guide tube 5, that is housing column 1 end portion.

Insulating means 4 are provided with a duct 6 housing column 1; preferably column 1 is also housed within an insulating sheath 6a that extends from means 4 inside guide tube 5. A further duct which houses connector cable 3, with an insulating sheath 7, e.g. in teflon, to insulate connector 3 from guide tubes is also provided at upstream means 4.

Conductive element 2 is usually positioned around the actual tip of the column end, that also protrudes from a wide bore portion 9 of insulator 4, i.e. the portion partially housing column 1 end portion and conductive element 2.

In the preferred embodiment shown in fig. 1 feeding means are provided in the form of a tube 17 that connects portion 9 of insulator 4 with a source of make-up gas, to help in transporting sample into the ion source 11.

In the preferred embodiment of the invention (as in fig. 2), insulating means 4, guide tube 5 and element 2 are all part of a probe unit 8 that can be interchangeably located at the interface of the MS equipment.

In fig. 2, probe 8 is inserted through a known vacuum lock 10 and is positioned near ion source 11 in the evacuated area of the MS. In this configuration the column 1 end is protruding into the ion source inlet, and the exiting eluent is nebulised

directly into the ion source.

Alternatively, the invention device may also contain a focusing plate 13 located between the end of column 1 and the ion source 11 and preferably mounted onto insulating means 4 by supporting arms 18 thus being part of probe unit 8 (figures 3 and 4). Note that supporting arms 18 prevent the focusing plate touching the source block when it is pushed through the probe lock (see fig. 3 and 4).

Plate 13 is provided with a sheathed cable, 19, 20 to connect it with a d.c. power source in order to apply to the said plate 13 a voltage that has a value intermediate between the voltage values of element 2 and of ion source 11. Supporting arms 18 are preferably made of insulating material, e.g. integral with insulator 4.

As previously disclosed, the invention device is suitable for interfacing LC and SFC equipments to a MS spectrometer. In the latter case, i.e. in a SFC-MS interface, heating means (not shown) are preferably provided to neutralize the cooling effect of the eluent expansion at its exit from the column restriction.

In figures 5-7 are schematically disclosed several different embodiments of the conductive element 2. As shown, besides the tube disclosed in fig. 1, element 2 may consist of a plurality of windings 2a (fig. 5), obviously interconnected, wound around an insulating support 14.

Alternatively, element 2 may comprise a plurality of interconnected spikes 2b (fig. 6) partially housed in supporting means 14b, or finally a circular plate 15 and several tangential plates 15a (fig. 7).

According to a preferred embodiment (not shown), the conductive element 2 consists of a metal plating, i.e. of a thin layer of metal directly deposited on the column end.

Most preferably the metal used for the conductive element is gold.

In all above disclosed embodiments, the position of the column end will be substantially the same as that shown in fig. 1, i.e. the column is slightly protruding from the conductive element(s) and from insulating means 4.

The peculiar configuration of the invention device enables a great flexibility of its use.

According to the invention, the method for interfacing LC or SFC equipment with a mass spectrometer is comprising the steps of positioning at least one conductive element adjacent the column end, locating said column end and the adjacent conductive element 2 at preselected distance from the ion source of the spectrometer, and connecting conductive element 2 to a high voltage source while grounding the ion source 11, or viceversa, to generate the required electrostatic field.

The conductive element 2 is, as above dis-

closed, usually positioned around and slightly upstream the column end, and the distance of the column end-conductive element from the ion source is preferably very small.

5 In this case, the interface device as a probe is positioned very near the ion source. The column end is protruding into the ion source inlet, and the eluent exiting the column end is nebulized directly into the ion source.

10 If a traditional configuration is used, i.e. with the column end more distant from the ion source, a focusing plate 13 is preferably positioned between column end and ion source. This plate is held at an intermediate voltage between element 2 and ion source 11 voltage values, to focus the spray of nebulised eluent into the ion source inlet.

15 As above disclosed, the electrostatic field is generated either by applying a high voltage to the conductive element 2 and grounding ion source 11 (at least, but preferably the whole equipment is grounded) or, viceversa, by grounding element 2 and applying said high voltage to ion source 11.

20 The first operating mode is schematically disclosed in fig. 3, and is implemented when interfacing to a quadrupole spectrometer is required. Element 2 potential is preferably about 4 Kv.

25 The latter operating mode is implemented when interfacing to a magnetic sector spectrometer is required. This case is schematically shown in fig. 4, where ion source 11 is preferably held at 4-5 Kv, while element 2 is grounded or held at a very low voltage.

30 In both cases, ionization may be obtained by classical and widely used techniques of electron impact or chemical ionization.

35 The invention will be further disclosed hereinafter by means of the following, non-limiting, example.

40 EXAMPLE I

Micro LC/MS analysis of a mixture of polycyclic aromatic hydrocarbons. The relevant total ion chromatogram of separation is shown in fig. 8.

45 LC CONDITIONS:

Column, 15 cm x 0.22 um fused silica packed with 5 um C18 HPLC material Eluent, 80% methanol/20% H₂O Flowrate, 5 ul/min.

PROBE CONDITIONS:

50 Probe as shown in figures 1 and 2 was used. Conductive element 2 at 3.5 KV source was grounded.

Source temperature 180 C No make up gas used.

55 MS CONDITIONS:

Quadrupole mass spectrometer, mass range 2-1000 amu, Electron impact source at 70 ev.

EI mass spectrum (A) of third eluting compo-

nent obtained from acquisition shown in fig. 1 (pyrene), and comparison with EI library spectrum of pyrene (B) are shown in fig. 9. This was the first spectrum selected on performing library searching of NIST Electron Impact library of 50000 compounds with a search score of 897/1000.

The previously referred to apparatuses for conducting LC-MS or SFC-MS analyses, provided with an interfacing device according to the present invention, are obviously a further object of the invention.

Claims

1. A method for interfacing LC or SFC chromatographic equipment with a mass spectrometer, comprising the step of nebulising the eluent exiting the equipment column end (1) by means of an electrostatic field, characterized in that it further comprises the steps of: positioning at least one conductive element (2) adjacent said column end (1); positioning said column end (1) and said conductive element (2) at a preselected distance from the mass spectrometer ion source (11); and connecting said conductive element (2) to a high voltage source and grounding said ion source, or viceversa.
2. A method according to claim 1, characterized in positioning a focusing plate (13) between said column end (1) and said ion source (11) and in applying to said focusing plate an intermediate voltage to focus the nebulised eluent spray.
3. A method according to claim 1 or 2, wherein said mass spectrometer is a magnetic sector spectrometer, characterized in grounding said conductive element (2) and applying a high potential to said ion source (11).
4. A method according to claim 1 or 2, wherein said mass spectrometer is a quadrupole spectrometer, characterized in grounding said ion source (11) and in applying a high potential to said conductive element (2).
5. A method according to claim 1, characterized in nebulizing said eluent directly into the ion source (11).
6. A device for interfacing an LC or SFC chromatographic equipment with a mass spectrometer, comprising means to generate an electrostatic field between said column end (1) and the spectrometer ion source (11) to nebulise the eluent exiting the column end characterized in that it is further comprising: at least one conductive element (2) positioned adjacent to the column end (1); means (3) to alternatively connect said conductive element (2) to a high voltage source or to ground them; said conductive element (2) and connecting means being at least partially positioned within insulating means (4,7) located at one end of a guide tube (5) housing the end portion of said chromatographic column (1).
7. A device according to claim 6, characterized in further comprising a focusing plate (13) located between said column end (1) and said ion source (11), said focusing plate (13) being provided with connecting means (19) to connect it to a source of an intermediate voltage.
8. A device according to claim 6, wherein said guide tube (5), insulating means (2) and focusing plate (13) are part of a probe unit (8).
9. A device according to claim 6, characterized in that said conductive element (2) is located upstream and around said column end (1), and said column end is protruding from the insulating means (4).
10. A device according to claim 6, characterized in that said column end (1) is protruding into said ion source (11) inlet.
11. A device according to claim 6, to be used with a magnetic sector mass spectrometer, wherein said conductive element (2) is grounded and said connecting means of the spectrometer ion source (11) are connected with a high voltage source.
12. A device according to claim 6, to be used with a quadrupole mass spectrometer, wherein said conductive element (2) is connected to a high voltage source and said connecting means of the spectrometer ion source (11) are grounded.
13. A device according to any claim 6 to 12, wherein said conductive element (2) is a metal plating provided on said column end (1).
14. A device according to any claim 6 to 13, wherein said conductive element (2) is made of gold.
15. A device according to any claim 6 to 12, characterized in further comprising heating or cooling means to control the temperature of the eluent exiting from the column end.

16. A device according to any claim 6 to 13 characterized in comprising further feeding means (17) for adding make up gas near the eluent exiting from the column end (1).

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17. An apparatus for conducting LC-MS analyses, characterized in comprising and interface device according to any claim from 6 to 13.

18. An apparatus for conducting SFC-MS analyses, characterized in comprising an interface device according to any claim 6 to 13.

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Fig. 1

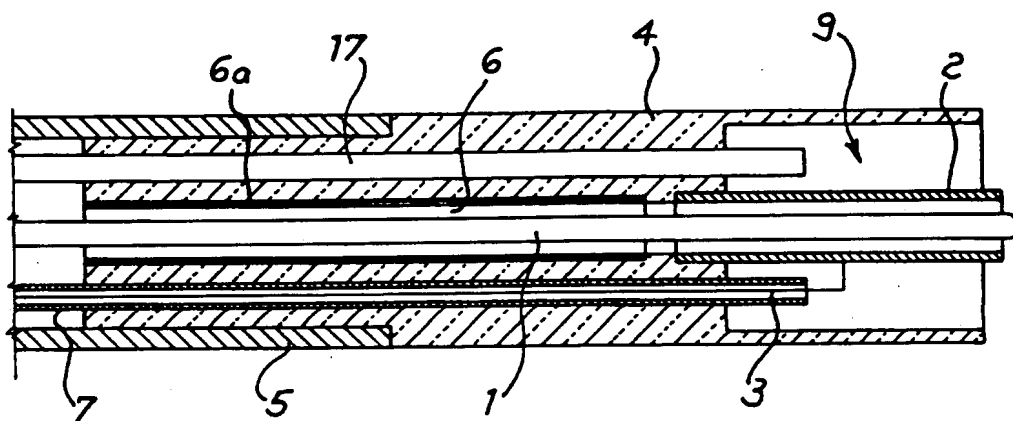


Fig. 2

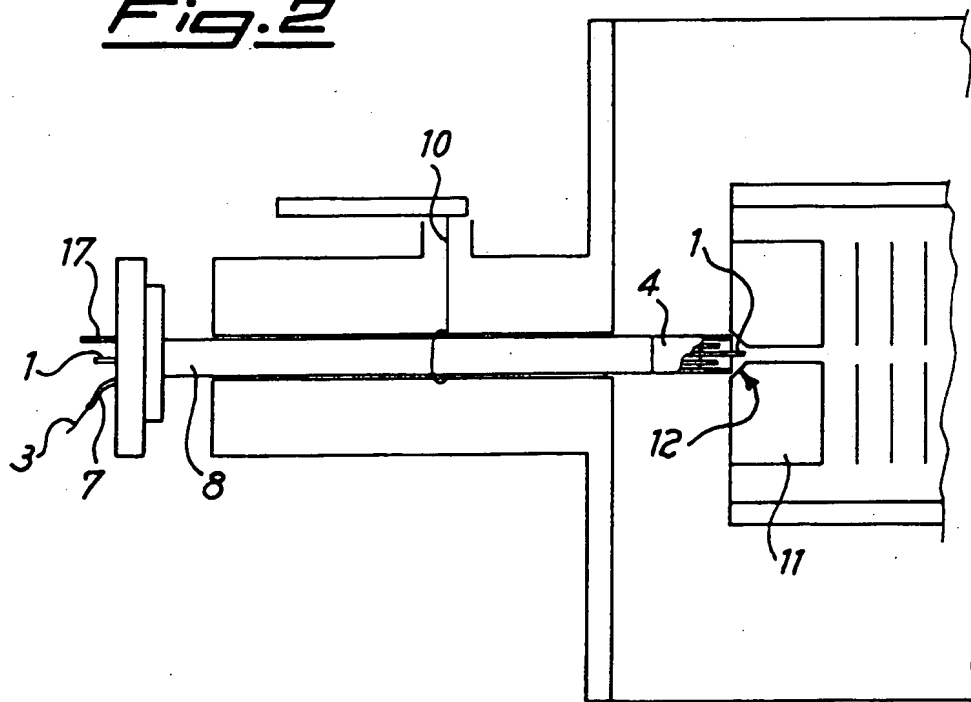


Fig. 3

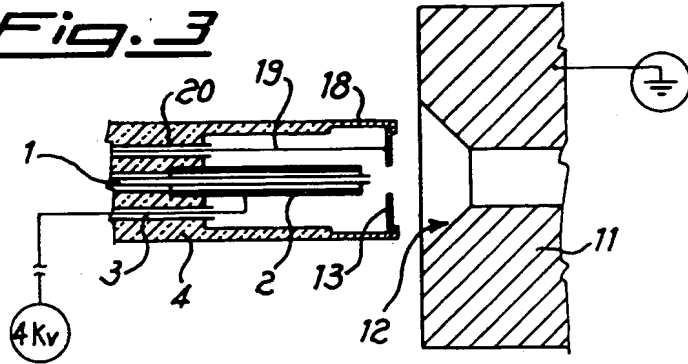


Fig. 4

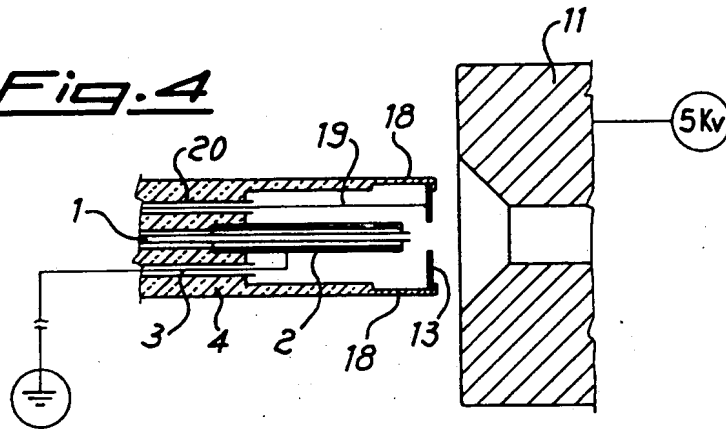


Fig. 6

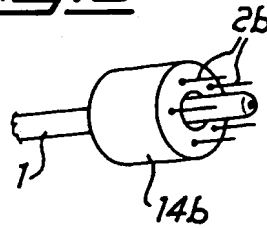


Fig. 5

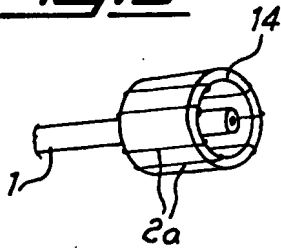


Fig. 7

